DOCUMENT RESUME

ED 369 388 IR 016 618

AUTHOR	Gardner, John; And Others
TITLE	Personal Portable Computers and the Curriculum. Practitioner MiniPaper 13.
INSTITUTION	Scottish Council for Research in Education.
REPORT NO	ISBN-0-947833-89-7; SCRE-Pub-120
PUB DATE	94
NOTE	63p.
AVAILABLE FROM	Scottish Council for Research in Education, 15 St. John Street, Edinburgh, Scotland, United Kingdom EH8 8JR (5.50 British pounds).
PUB TYPE	Books (010) -- Reports - Evaluative/Feasibility (142)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Computer Literacy; *Computer Uses in Education; Curriculum Development; *Educational Technology; Elementary Secondary Education; Foreign Countries; Information Literacy; Information Technology; Microcomputers
IDENTIFIERS	Laptop Computers; Learning Environments; Northern Ireland; Scottish Council for Research in Education

ABSTRACT

This book considers a variety of issues relating to the use of portable computers in the school. It is based on the study the Pupil's Learning and Access to Information Technology (PLAIT) in Northern Ireland. The PLAIT project introduced 235 portable computers in 9 schools for use in English, science, and mathematics course. Following an introductory chapter, the second chapter explores the place of computers in the curriculum. The third chapter reports on the findings of the project in relation to the potential contribution of portables to the of teaching the main curriculum subjects. The fourth chapter explores the effects of portable computers in the classroom in terms of schedule, technical support, teaching issues, organization, software, and hardware. The general conclusions of the study, presented in the final chapter, are that the portable computers had resulted in high levels of pupil motivation, harmonious and purposeful learning environments, and greatly accelerated information technology literacy among the pupils and teachers alike. (JLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 369 388

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY

R.N. Tucker

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR 016 618

Practitioner MiniPaper (PmP)13

Personal Portable Computers and the Curriculum

John Gardner, Hugh Morrison,
Ruth Jarman, Clare Reilly, Helena McNally

BEST COPY AVAILABLE

Personal Portable Computers and the Curriculum

John Gardner, Hugh Morrison,
Ruth Jarman, Clare Reilly, Helena McNally

SCRE Publication 120

Practitioner MiniPaper 13

First Published 1994

Series editors: Wynne Harlen
Rosemary Wake

The views expressed are those of the authors and do not necessarily reflect those of the Scottish Council for Research in Education or of the funder of the research.

ISBN 0 947833 89 7

© The Scottish Council for Research in Education 1993

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system, without permission in writing from the publisher.

Printed and bound in Great Britain for the Scottish Council for Research in Education by Inglis Allen, Kirkcaldy.

ACKNOWLEDGMENTS

We would like to acknowledge the foresight of the Department of Education for Northern Ireland in sponsoring the research project described here and would also like to express our gratitude for the support and guidance of the project advisory group: John Anderson, Michael Montgomery, Richard Naylor, Mary Robinson, Rosemary Stevenson and Nick Todd. Sincere and special thanks are also due to the schools, pupils and teacher-researchers who worked so hard to make the project a resounding success. A final word of thanks is due to the Scottish Council for Research in Education for providing this vehicle for the research findings; and to Rosemary Wake in particular for her editorial advice.

John Gardner, Hugh Morrison, Ruth Jarman, Clare Reilly, Helena McNally

August 1993

CONTENTS

page

1. Introduction 1

2. Computing in Schools 3

The rationale for computers in the classroom 3
What is computer literacy? 4
Learning about computers 5
Learning with computers 5
Learning through computers 6
Moving from unfamiliarity to competence 7
The scope of information technology literacy 9
Wordprocessing 9
Databases 9
Spreadsheets 9
Information technology and the curriculum 10
Communicating information 10
Information handling 10
Modelling 11
Measurement and control 11
The impact of information technology on society 12

3. Learning from the Project 13

Portables in the English class 13
Information technology and the English curriculum 14
Desk-top publishing 14
Drafting and redrafting 15
Writing for specific audiences 16
Curriculum enhancement 16
Pupils with special needs 17
Collaborative working 17
Assessment 18
Impact on writing 18
Keyboard skills 18

Portables in the science class 19
Wordprocessing 19
Pupils working autonomously 20
Class sets of portables 20
Using databases 21
Using spreadsheets 21
Modelling and simulation 21
Measurement and control 22
Awareness of what IT offers 23
Assessment 23
Lesson planning and preparation 24
Teaching and learning styles 25
Portables in the mathematics class 26
Information technology and the mathematics curriculum . 26
Information and data-handling 26
Number and measurement 27
Shape, space and movement 27
Using spreadsheets 28
Using Logo 28
Using database software 29
Using drill software 29
Pupils working autonomously 30

4. Portables in the Classroom 31
Developing teachers' IT competence 31
Implications for the teaching schedule 32
Lesson length 32
Planning and pacing lessons 33
Technical Support 33
Teachers as providers of technical support 34
Decreasing the impact of problems 34
Networks versus portables 34
Teaching Issues 36
'New' modes of pupil contact 36
Teaching effort 37
Pupils without machines or disks 37

Catering for absentees 37
Printing out pupils' work 38
Contingency strategies 39
School and classroom organisation 39
Aspects of the classroom 39
Lighting and screen quality 40
Location of equipment 41
Power 41
Software 42
Ease of use 42
Variety of software 43
Virus protection 43
Guides 44
Hardware 44
Robustness and durability 44
Reliability 44
Protective carrier bags 45
Portability 46
Warranty and non-warranty machine problems 46
Supplier support 47
Password protection 47
Insurance 48
Disk storage 48
User Interface 49
Memory 49

5. Some Conclusions 51
References and further reading 54

1

INTRODUCTION

PORTABLE COMPUTERS are, to all intents and purposes, smaller versions of the common 'desktop' machine. Depending on their configuration, they can be as powerful as desktop machines but they have one major additional attribute. Instead of taking the work to the computer, the lightness and design of portables enables them to be carried to the place of work - to the school desk, to the library, on the field trip... Portable computers, therefore, hold out the promise of putting convenient and personalised computing power not just in pupils' hands but in teachers' hands too.

In view of the perceived potential of these machines, the Department of Education for Northern Ireland decided to investigate the practicalities of introducing them into the classroom. Two hundred and thirty-five machines were placed, in complete class sets, in nine schools (one primary, one special education and seven secondary) for pupils and their teachers to own during a whole school year. The project was known as the PLAIT project (Pupils' Learning and Access to Information Technology). Most of the classes were of pupils aged 12 to 14, with one class of 14 to 15 year olds and one of 10 to 11 year olds. Although pupils were free to use the machines in all of their lessons, the 'focus' subjects were English, science and mathematics.

This booklet considers a variety of issues relating to the use of portable computers in school. In the first chapter we discuss the place of computers in the school curriculum before moving on, in the second chapter, to report the findings of the project in relation to the potential contribution of portables to teaching of the main curriculum subjects. Since, however, it is important not to lose sight of the realities of using such high levels of technology in the classroom, the subsequent chapters focus on the practicalities and pitfalls, for schools and teachers alike, of

one-to-one pupil use of portable computers. The report is based on the observations of the research team, tests and questionnaires completed by the pupils and the experience of teachers and pupils as noted in diaries which they kept for the purposes of the project.

The machines used in the project were the Research Machines Ltd NB201s, Toshiba T1000SEs, Apple Powerbook 100s and Tandy WP2s. The first two of these are IBM-compatible with 1Mb RAM and 1.44 Mb 3.5 inch disk drives while the Apple Powerbook is compatible with desktop Macintosh machines. The Tandy WP2 is a relatively simple machine with proprietary wordprocessing software in ROM. The reader should note that in writing this report the authors have tried to focus on classroom rather than hardware and software issues. Such is the pace of change, and the regular updating of hardware in particular, that improvements – some of them no doubt arising from this work – are constantly being made.

2

COMPUTING IN SCHOOLS

THERE SEEMS to be no let up in the pressure on schools to integrate 'information technology' or 'IT' into the curriculum. Schools are constantly exhorted to turn out pupils as computer-literate whizzkids – capable of exploiting the new technologies and mastering the intricacies of commerce and industry - so as to create nations of great wealth and plenty. There is an accompanying expectation that we, the teachers, will deliver this technically literate and successful generation. There are, of course, some major problems standing in the way. These can be summarised in a number of simple questions: what is this computer literacy we are charged with delivering? How can we deliver what most of us don't have ourselves? and, once we know what it is, how do we go about it? and how can we provide all pupils with sufficient access to the necessary computing facilities? It is not possible to answer such questions fully here but our intention is to shed some light upon the issues, especially on those related to the classroom, by sharing the experiences gleaned from the major project on which this booklet is based.

The rationale for computers in the classroom

The pressure on schools and teachers to integrate information technology into classrooms arises on a number of fronts. Firstly there is the perception, shared by government, employers, parents and indeed pupils alike, that 'doing computers' makes pupils more employable. Whether or not this is true, the perception is sufficiently strong as to create a continuous and vociferous lobby for pupils to develop such skills. Employers appear to want a workforce literate in information technology, so it seems it is up to teachers to deliver the goods.

Secondly, there is the view that the use of computers can contribute to higher pupil motivation, better quality of pupil

work output and generally more purposeful and harmonious learning environments. There is certainly more evidence for this and computers are widely accepted as being useful in supporting and enhancing aspects of classroom work.

Thirdly, there is the view that if computers can liberate pupils from, for example, the tedium of repetitive or long calculations or from the untidiness and confusion of handwritten drafting and redrafting, then pupils' creative abilities can be given free rein and their learning can be improved. This is a less researched area where conflicting views exist. On the one hand, there are those who consider that conventional learning, as assessed by conventional techniques, is only marginally enhanced, while, on the other hand, there are those who consider that computers introduce new styles of learning which cannot be assessed conventionally but which have no less importance in a pupil's education.

While these debates are of significant interest to schools, they tend, in the main, to take up the time of academics and to some extent of policy-makers. The primary concerns for schools remain constant, and these reflect practical matters related to teachers' confidence and competence in the use of computers, teachers' time and access to computers, and the provision of sufficient resources for teachers and pupils to use.

What is computer literacy?

Computer literacy, or in its broader form information technology literacy, covers an array of technologies which confront us daily: automatic bank tellers, barcode checkouts, broadcast information systems like *Ceefax*, satellite television, compact-disk-based information banks, visual display systems. All of these, in some way or another, enable us to store, process and communicate types of information. At the centre lies the computer with its ability to process large amounts of information quickly and conveniently. This information is usually text or numbers but it can just as easily be images, video or sounds or indeed any combination of these – so-called 'multi-media' information.

Literacy in these contexts means both a familiarity with the various forms of the technology and the ability to use technology in a natural and competent manner to meet our own needs and, where appropriate, those of others. Current wisdom is that in order to develop this literacy in pupils we must provide them with a learning environment which enables them not just to learn *about* computers but also to learn *with*, and in some cases *through*, computers.

Learning about computers

This is something we all have to do but it is important that we are clear about what we mean. For all but a tiny, specialist minority it is less important to know how computers work than to know how we use them (we all know how to use a television but do we know how it works?). Clearly, pupils need to know how to use computers in order to exploit them in their learning, but knowing the language which a computer uses will not be useful to most pupils.

Learning with computers

This is the most important of the learning trio. Again, received wisdom is that if we use computers to support pupils' learning, right across the curriculum, they will develop computer literacy automatically and will benefit from a better educational environment. Thus, the argument goes, if pupils experience the uses of computers in all aspects of their schooling (including the administration of the school), they will leave compulsory education ready and able to confront and exploit these new technologies in any walk of life – information technology will be a fully assimilated and natural feature of their development.

One fast-developing context for learning with computers, particularly in staff development, is interactive video. Interactive video disks are like compact disks in certain superficial respects (for example, they are like 12 inch versions of compact disks) but they almost exclusively store moving video (with appropriate audio) sequences instead of the text, sound and still image mixes which compact disks usually contain.

School-based interactive video training disks currently available include Managing Time (for school principals), Skills for Appraisal Training (for appraisers and appraisees) and Teaching Secondary Maths (all from the Scottish Interactive Technology Centre, Moray House Institute of Education, Edinburgh) and the Quality Management in Schools (QMS) disks (produced by the Northern Ireland Centre for Learning Resources, Stranmills College, Belfast). Each training disk contains video sequences which present carefully scripted scenarios designed to cause the teacher to analyse and reflect upon the event or processes involved. Staff can choose when to study the materials and the usual follow-up is for the teachers who take the course to meet regularly with a staff development coordinator or mentor to develop and discuss issues, and ultimately to consolidate the training gains from the work.

Learning through computers

This is a more contentious area than the other two as it implies that the students' learning is mediated by the computer and not by a teacher – the machine is the facilitator of learning. Computer-based learning (CBL) or computer-assisted learning (CAL) of this type attracts ever more interest, particularly in higher education where the numbers enrolling in universities and colleges continue to rise dramatically. With no increase in staffing, many institutions are looking to computers to provide routine and foundation teaching, thus releasing staff time for research and 'quality' student contact, for example honours tutorials. Computer-based learning takes various forms: it might be a set of multiple-choice questions for practice, a tutorial between student and computer where the machine leads the student through an information-explanation-assessment cycle, or an elaborate simulation of some event or process which the student has to study and then make inferences from.

Another form of self-study based on new technology is beginning to establish an important place in resource-based learning. Multi-media databases can be designed to increase students' control over their learning by enabling them to access

large banks of resources on compact disk. Thus the learner might browse through a database on a particular period of history, complete with facsimiles of primary sources materials (old maps, letters, manuscripts etc) which can be collated and printed straight from the disk. Many institutions, including schools, now offer the opportunity to search for information on any chosen topic on compact disks containing several years' complete archive of all copies of major newspapers, such as the *Times* or the *Guardian.*

Both computer-based learning and technology-based learning resources are making an impact in schools. Computer-based learning packages are common throughout the curriculum but instead of replacing conventional teaching they tend to be used to support teaching and to enhance the study topic. Resource-based learning approaches are on the increase as information sources on CD become common in school libraries.

Moving from unfamiliarity to competence

Lack of familiarity when confronted with new equipment is the first problem we all face. How many of us, when we first used a bank's 'hole in the wall' teller, attempted to put the card in the wrong slot or upside-down? How many, even those of us who might describe ourselves as technically literate, can sit down at a new computer or word-processor in the confidence that we will get going straight away?

It is often said that technical familiarity and confidence is linked to a certain brashness which adults rarely have but youngsters have in plenty. While pupils will try everything with gay abandon until they get the machine to do what they want we, in the same circumstances, grow red-faced with frustration and despair.

Many adults find it difficult to acknowledge that they do not know as much as they would like and this translates into a lack of confidence and a reluctance to become involved with computers. We worry about our inability to type and the possibilities of damaging the machine. These are not important concerns. Once

people get past the 'hunt and peck' typing stage, they usually become proficient two- and even one-finger typists. Furthermore, it is extremely difficult to damage a computer - none of the thousands of learners we have dealt with has ever managed to do any harm.

Once people achieve a basic familiarity, most can build a technical repertoire quite quickly – given the necessary time and access to computers. The first level of familiarity is knowing the keyboard and the normal functions of keys. Keys like the SPACEBAR, the ENTER or RETURN key, the ESCAPE key and the DELETE or ERASE key become familiar first, followed, as practice continues, by the CONTROL key, the TAB key, the CURSOR or ARROW keys and so on. 'Mice' can take a little longer to master, as we practise and coordinate hand movements and button-clicking, while 'menus', which provide a choice of useful shortcuts, are usually soon appreciated.

Gradually learners begin to understand the processes of storing (saving) and retrieving (loading) work, and becomes confident in using their own set of favourite disks. Once we have used a program several times we can be reasonably confident that we 'know it' and it becomes relatively easy to integrate it into our teaching. There are, of course, certain programs which have many sophisticated functions and features. Practice with these allows us to develop a minimum working competence to do most of the things we need, and our confidence reassures us that we will know how to use the manuals to solve any problems which arise.

During these learning and practice sessions we begin to internalise our understanding of the computer and its applications. We begin to appreciate that certain processes and procedures are common and, in much the same way as we appreciate that most cars will have a steering wheel and windscreen wipers, we begin to expect most wordprocessors to have procedures for moving blocks of text, for checking spelling and for choosing alternative typefaces. However, we usually do not feel confident that we can face new wordprocessors or other unfamiliar pieces of software until this grasp of the concepts takes hold.

The scope of information technology literacy

As we pursue confidence and competence, we need to keep the extent of our needs in sight. Essentially, information technology for most teachers and pupils means a core set of software applications: wordprocessing (for communicating information usually in the form of text), databases (for storing and retrieving information again usually in the form of text) and spreadsheets (for carrying out mathematical operations on numerical information).

Wordprocessing

Everyone has a need for wordprocessing. The power and convenience of wordprocessor technology for communication of the written word is almost unchallenged today and most people, whether inside or outside education and commerce, have some familiarity with the concepts if not the practice.

Databases

While many people may not be familiar with the label 'database' or with specific packages, the concept is recognised and widely accepted in such forms as filing records or library catalogues. A database is essentially a structured set of information which we can search through. Once we are familiar with the means of 'interrogating' one electronic database, it is usually not very difficult to attempt to use a different one.

Spreadsheets

In so far as they derive from their paper equivalents in conventional accounting, spreadsheets are most clearly attractive in subjects involving numbers such as maths and science. Spreadsheets are probably the least familiar, and perhaps the least useful, application for most people yet they are proving valuable in subjects as diverse as home economics (for example in planning diets or home decoration) and geography (for example for weather monitoring and field sampling measures).

While there are other applications of information technology with varying degrees of importance for education, including

electronic mail, interactive video and robotics, it is wordprocessing, databases and spreadsheets that are widely seen as being of central importance. How might they be used within the framework of the curriculum?

Information technology and the curriculum

Over the past 10 years or so ideas about information technology in the curriculum have gradually been refined to the point where we can define five 'strands' of application or pupil learning activity. In essence, these comprise two general applications areas (communicating information and information handling, two specialist areas (modelling and measurement and control) and a strand which covers awareness of the 'uses of computers and their implications for society' (SOED 1991a). Let us now examine the curricular processes these strands relate to.

Communicating information

The first strand, communicating information, is linked primarily to wordprocessing and finds its curricular 'home' in the writing aspects of English. The pupil activities which come under this strand include drafting and redrafting written tasks; revision, proof-reading and editing; writing for different audiences and writing in different styles (for example, narrative, discursive and formal). Extensions of this within the English classroom often include the use of desktop publishing software to create magazine-type publications and the use of electronic mail software to engage in remote national or even international communication with other pupils. Using writing for communication is obviously not specific to one area of the curriculum, so wordprocessing for this strand of a pupil's developing information technology literacy can be addressed in many subjects.

Information handling

The second strand, information handling, is also cross-curricular. It represents the processes used to gather and store information and the ways in which we structure and interrogate it. The most obvious application – the database – may take many forms. There are databases which we use but to which we do not

contribute, for example a compact disk containing all of the year's stories from the *Times* or materials on *Ceefax*. Alternatively, pupils may use commonly available packages to create their own collections of information or databases, whether it be from field trips to examine life on the seashore or from surveys of pupils' likes and dislikes in music. Large collections of information can be stored in the computer where subsequent analysis can identify patterns or trends.

Modelling

Modelling is a specialist strand which relates primarily to science and mathematics but there are many applications across the curriculum. At its simplest, modelling covers the computer-assisted learning concept of simulations, where the computer simulates an event or process, generally by means of text but possibly also through a combination of text, animated graphics and video. For example, packages are available which enable pupils to explore the events of the First World War or the management of domestic finances. Simulations – and their sometimes 'fantastic' derivatives, adventure games – are renowned for motivating pupils and stimulating discussion. Modelling proper, on the other hand, is the process by which pupils themselves attempt to model a real-life event or process by making and testing out hypotheses. For the most part, such activities require some form of mathematical relationship between the elements of the model but this can be as relatively simple as finding the geometric rules which govern the creation of a shape, such as a triangle, using the special computer language, Logo.

Measurement and control

Measurement and control involves specialist activities and is also most commonly associated with science and technology. For example, pupils can monitor their science experiments, 'capturing' or 'logging' a variety of measures such as temperatures, light levels or humidity levels using special sensors connected to the computer. Once the computer has the data, pupils can process it to plot graphs, prepare tables and identify patterns and relationships. In technology classes, pupils can design and

implement simple artefacts based on electronic parts (such as a burglar alarm). This may often involve 'control' in terms of pupils instructing the computer to direct a small robotic device. Outside the areas of science and technology, there are opportunities for pupils to use computer-based measurement in, for example, geography fieldwork.

The impact of information technology on society

The final strand, relating to computers and society, does not involve a particular type of application but covers the need for pupils to appreciate how information technology impacts on all aspects of society, including banking, telecommunications, satellite transmissions, stock control in shops, travel planning... Social implications, in terms of new patterns of working and new patterns of job opportunity, are also high on the agenda for this area of study.

How schools might go about making pupils computer literate while teaching key areas of the curriculum, and the practical implications of using portable computers to this end, was what the PLAIT project was about. The findings are described and discussed in the next two chapters.

3

LEARNING FROM THE PROJECT

AN IMPORTANT OBJECTIVE of the PLAIT project was to investigate the extent to which portable computers can contribute to the delivery of various school subjects. All but two of the nine classes involved in the project were in the 12 to 14 age range, the others being one class of pupils of aged 14 to 15, and one of 10 to 11 year olds. The classes included five co-educational groups and two each of single-sex boys and girls' classes. Although the pupils were free to use their portable computers in all their lessons, the 'focus' classes were English, science and mathematics. The research used a variety of qualitative and quantitative techniques chosen to be 'fit for purpose'. Teachers and pupils kept diaries; and interviews were conducted to provide detail of classroom activities. Classroom observations were carried out by the research team and pupil performance and attitudes were measured using appropriate tests and questionnaires. The results reported represent a compilation of the work of all of the teachers and schools, and of the observations of the research team.

As mentioned above, the project focused on English, science and mathematics. In the next three sections we will explore what portable computers could and could not do. It should be noted that the references to 'focus teachers' relate to those teachers who had a special responsibility to report on the use of portables in a particular subject. 'Non-focus' teachers taught the same class as the focus teacher but for a different subject.

Portables in the English class

The project revealed a significantly high degree of usage of the portable computers in English, the large majority of the activities involving wordprocessing. Focus teachers reported very positively on the impact of portables in this subject and their views were shared by the other non-focus teachers of English (ie, teachers of English in schools where the focus was science or mathematics).

Information technology and the English curriculum

The project showed that the use of portable computers could address all the IT-related dimensions of the English curriculum. Although the content of this curriculum differs in emphasis and detail for Scotland, Northern Ireland, England and Wales, a common structure derives from the activities of reading, writing, talking and listening. While there is perhaps less emphasis on IT in English than in subjects such as mathematics and science, there is reasonable consensus on how it can contribute to the curriculum. This is nicely summed up by the following extract from the SOED's *Guidelines for English Language 5-14:*

> The key uses of the microcomputer for language development are word processing, desk-top publishing, information handling, adventure games and simulations. All of these may stimulate thinking, reading, writing, listening and talking. Word-processing improves the quality of pupils' writing by releasing them from problems of poor coordination in handwriting, and allows them to concentrate on the content, organisation and editing of their own work. It creates a sense of audience and purpose and encourages the development of all the English language components through an active, naturally integrated process. As a medium for creativity, it can foster thinking and critical self-awareness and is a natural extension to drafting and redrafting. Since several pupils are able to plan and organise ideas directly on screen, word-processing is also a catalyst for paired and group work. As text unfolds, it is easy for them to read and discuss content, structure, spelling and punctuation, to evaluate and learn to value the contribution of others. (SOED 1991b)

Desktop-publishing

The main activities addressed by teachers during the project included designing the front page of a magazine using desktop publishing. In one class this was carried out in the context of creating a school news-sheet. Another class experimented with letter formats and different layouts for poetry and newspaper texts. The classes produced displays which the teachers considered to be very satisfying work. One teacher reported: 'This is perfect classroom work as audience awareness, presentation and language

skills are all involved'. There was evidence that this desktop-publishing activity was being closely linked with normal classroom reading of novels, poetry etc.

Drafting and redrafting

Pupils were able to plan, compose, revise, and redraft their writing using their portables, in discussion with the teacher or classmates. This was achieved successfully by all the primary and secondary pupils and there were positive comments from teachers about the usefulness of this kind of activity. Pupils showed independence in planning, revising and redrafting their writing. The primary pupils took notes using the portable, organised the information, printed it and then shared it with other groups. In one secondary school pupils analysed the letters of a group of primary children to Santa Claus and then organised this under a series of headings before constructing replies.

The facility for fast and efficient editing was appreciated by teachers and pupils alike and was considered to have contributed to significant improvements in pupils' output. The worry that personal machines might detract from collaborative work did not manifest itself, pupils happily cooperating and consulting with each other.

Pupils regularly turned to their wordprocessor spell-check and dictionary facilities, teachers reporting these had 'made a significant contribution to presentation of accurate work' and were used 'with enthusiasm'. There were reports of an increased awareness of the need for accurate spelling among pupils, and of a degree of independence on the part of pupils in using spell-checkers without teacher intervention. The former was corroborated to some extent by the evidence from testing carried out in the project on pupils' writing. This indicated superior performance by the groups with access to portables, as against that of the control groups without portables, in detailed analyses of their writing, and in particular the number of spelling errors per 100 words.

Pupils became more aware of the need for correct spelling to the extent that they were more likely than before the introduction

of the portables to turn to conventional dictionaries for spelling checks. There were also reports that pupils tended to use dictionaries more often to check spellings when the spell-check had failed, or where they were unable due to lack of knowledge to select one of the options offered. Pupils' appreciation of the 'technical' aspects of writing was viewed as an ongoing development and the pupils were thought to show a 'better awareness of punctuation, paragraphing and formats than before and [could] appreciate these aspects of writing more clearly'.

As an aside, it is interesting to note also that the pupils began to use 'spell-check' as a verb and were quick to criticise wordprocessing software which did not have a spell-check facility.

Writing for specific audiences

Writing which was designed to be attractive to other audiences in terms of layout, illustration, style and so on was accomplished using the portables in all the schools. Most of the groups created materials for their school foyers and the work was described as having a high level of accuracy and good presentation. As mentioned above, one of the secondary level schools produced Santa Claus letters for primary school children, but this school's work gained special recognition when an anthology of short stories they created was published by the local authority. Another group sent letters to outside agencies. The primary group prepared illustrated short stories for the infant classes.

Curriculum enhancement

In the case of the primary class, much more was felt to have been achieved in terms of meeting curriculum objectives than would have been possible without the portables. The writing competence of pupils, according to the teacher concerned, was beyond the level that she would normally have expected of them. Pupils had increased their awareness of varieties of form and had developed a greater sense of audience. The setting for writing had been extended beyond teacher and pupil interaction to a wider audience. Pupils were more aware of the craft of writing and, in the words of one teacher, were 'more tuned-in as writers'.

The pupils were skilled in wordprocessing, and could master all the techniques from simple 'keyboarding' to 'cut and paste', drafting and redrafting, using the spell-check and so on. Even the less able pupils were capable of producing a 'reasonable' piece of work, which they would check for spelling before giving to their teacher. According to one teacher:

'I doubt if any class in any primary school in the Province could handle this work as well as they can ... I feel that the work they do drafting and redrafting on the computer has begun to transfer into their handwritten work. I have begun to see better punctuation and paragraphing...'.

This comment was borne out by the tests of writing ability that were conducted during the project.

Pupils with special needs

In the special needs setting, access to a personal portable had a very positive impact as a personal writing tool. Pupils with very poor handwriting skills were able to achieve a great deal because their writing was more presentable. The teacher felt that using computers had enabled her to begin tackling writing skills in a more focused manner. Drafting and redrafting was refined over time with the result that pupils were eventually able to produce a finalised piece of work in perhaps only two drafts instead of four. They had become much more aware of the need for thinking about writing before they wrote, in terms of planning a structure, contents, awareness of audience and so on. Apart from these skill-based considerations, the teacher reported increased confidence on the part of the pupils as writers.

Collaborative working

Collaborative pair and group work was used widely. Activities included pupils producing a collective piece of work and pupils reading or listening to each other's output. Teachers reported that pupils were more willing to allow their work to become public and had increased self-esteem and self-confidence. Individualised ownership of the machines did not appear to work against collaborative writing.

Assessment

Teachers reported carrying out assessment successfully using the portables. Assessment of layout, paragraphing, presentation of writing etc for wordprocessed work was considered to be relatively convenient, while assessment embracing content, appropriateness of language for context, awareness of audience and vocabulary was made easier by the relatively easy-to-read typescript. Ready access to the portables and printing facilities enabled teachers to keep evidence of good pupil work much more easily than if they were relying on work which had been carried out on a computer network. The work was produced much more quickly on the portable, and teachers were able to build up files of pupil course-work with copies conveniently retained by pupils.

Impact on writing

The work produced was felt to be more developed, more imaginative and longer than would normally be expected for a handwritten task of the same kind. However, transfer to general writing skills was tested empirically using writing tasks which enabled comparison between the groups with portables and the control groups. While they were not significant statistically, results indicated that on quality and creativity measures the 'portable' pupils did not fare as well in contrast to the objective measures of spelling and so on mentioned above.

Keyboard skills

Only one of the schools had a policy of teaching typing in the first form and the pupils reported that this was helpful for using the computer. Some pupils said they would like keyboard skills to be taught; others reported that they still preferred to take notes using pen and paper since they found this less time-consuming than using the portable. However, most pupils seemed capable of typing at a reasonable speed after some practice.

Since few of the pupils could type as fast as they could write by hand, the matter of length of work, referred to above, requires additional comment: while access to the portables may have

motivated pupils to create longer pieces of work in the long term, in the short term pupils would probably produce less. Some pupils were severely hampered by their lack of typing skills. Pupils' oral work showed an improved confidence and pupils were more expressive and capable of contributing to discussions.

The English teacher in the special school reported a definite improvement in the standard of course-work, especially presentation and content. In addition, the morale of the pupils concerned was reported to have been high.

Portables in the science class

The findings of the project draw extensively on the experience, both observed and reported, of the schools in which the portable computers were used in science. Without reservation, the teachers involved considered that the machines enabled them to address all the IT aspects of the science curriculum.

Wordprocessing

Predictably perhaps, the teachers in the project chose to start with wordprocessing as a means of familiarising pupils with their machines and as a means of addressing the 'communicating information' strand described above in relation to the needs of the science curriculum. The most obvious example was of pupils using their computers to make a written record of their experimental work. At first pupils' reports were often disjointed and progress slow. With editing so easy, however, teachers were able to intervene to suggest improvements and, as a result, they noted a rapid advance in terms of organisation and layout.

Although the process remained slower than handwriting, the quality of the work was high and pupils showed pride and pleasure in the product. In one school the pupils were already quite proficient in wordprocessing as a result of their work in timetabled IT classes the previous year. They used their personal computers to draw up plans for investigations and problem-solving activities. One pupil made a particularly notable comment: when asked if it would not be easier to use pencil and paper, she insisted she would rather use the computer, 'It makes me feel

27

more scientific,' she explained. This motivation was found to persist throughout the project. Pupils also used their personal computers to wordprocess written assignments on topics as diverse as space exploration and pollution. Again, work of quality was produced.

Pupils working autonomously

Although there were occasions when teachers issued explicit instructions that pupils should wordprocess their work, pupils often exercised considerable autonomy. Usually pupils themselves chose how they wished to present their written reports and there were instances of pupils having typed up information which had not been requested by the teacher. Thus one primary pupil wrote in his diary, 'I also added some of my own work to my computer, a list of the elements (substances that cannot be broken down into anything) eg. Au gold, Sn tin, Ne neon, etc etc'.

In as much as they tutored each other in the technical use of the machines, pupils worked collaboratively. Individuals also demonstrated a degree of autonomy in the use of their machines, as exemplified in a small-scale study with one of the classes. The pupils were invited to pose problems in science and to plan, perform and report their own practical investigations to solve these problems. This gave the teacher an opportunity to explore how much the pupils, when working independently, exploited their computers in their work. The outcome was encouraging as all the pupils used the portables in at least one aspect of their investigations. Wordprocessing, predictably, was the most popular application but many pupils also used spreadsheets to present their findings in the form of tables and graphs. A few pupils used sensors to collect experimental data but, curiously perhaps, none used databases. When such programs were used, they were almost always used appropriately and, in the context of individual investigations, the ratio of actual use to potential use was high.

Class sets of portables

Some of the teachers felt that having a class set of, say, ten machines in the laboratory would be a particularly useful

arrangement instead of having one with each pupil. In effect, most of the classes had only a limited set of sensor and other peripheral equipment so it was never possible to have all the pupils using sensors at the one time. Group working with a smaller set of machines in operation was found to be quite acceptable for experimental data-logging work.

Using databases

Pupils also undertook a range of data-handling activities (addressing the 'information handling' strand) using their portables. In the primary class, pupils extended their use of computers to the preparation of databases in support of a cross-curricular project on 'energy'. In the secondary classes, pupils created and interrogated databases on topics such as the periodic table, the nutrient components of food and the Earth in space.

Using spreadsheets

Pupils used spreadsheets to present the results of their investigations in graphical form. However, as one teacher observed, 'It's almost too easy to draw a graph on screen!' Teachers were anxious that their pupils should not lose the skill to construct graphs for themselves.

This is an important matter. Competence with information technology should complement rather than replace those key skills which pupils require in science and in everyday life. At the end of the project, however, when pupils' performance in a science test was analysed, the results suggested that pupils' data-handling skills had not suffered. The test had an emphasis on drawing graphs and was confirmed to be highly reliable. All the portable computer classes showed superior gains in comparison with the control groups (matched classes without portables) but it should be stressed that statistically significant differences were found for only one group (a group with the highest ability pupils).

Modelling and simulation

Least work was undertaken in relation to 'modelling'. Using spreadsheets, one teacher did attempt mathematical modelling with data derived from an experimental investigation on the

stretching of springs. Albeit with some effort, the class was able to arrive at Hooke's Law. Scientific simulations, on the other hand, were not used. This did not reflect a lack of awareness by teachers of the value of such activities, nor a lack of ability to incorporate them into their teaching programmes. Rather, it was a resource problem. The simulation software at the teachers' disposal was designed for use on BBC computers and no suitable software was available to them for their class portables which were primarily IBM-compatible.

Measurement and control

When interfaced with sensors, the data-capture capability of the portables proved to be particularly productive in supporting scientific investigations and addressing the 'measurement and control' strand. Interestingly, this application attracted the most favourable comments from teachers, indeed, it was suggested that, 'If portables did nothing else, they would be worth it for their data-logging facilities,' and 'Given more sensors, the sky's the limit'. Sensors were used in physics, chemistry and biology investigations and teachers commented on how they were looking forward to extending this type of work in the future. Teachers were impressed by the speed with which the pupils became proficient in the use of sensors and the associated software and hardware. Interestingly too, it was here that pupils showed the greatest readiness to propose their own lines of enquiry. The pupils in one class, for example, while studying the effects of acids on metals, learned that heat was given out during the reaction. They subsequently used their sensors to investigate the rise in temperature, an activity which would not normally be attempted by second form (12 year old) pupils. In another class pupils were encouraged to ask their own questions, to formulate simple hypotheses and to test their ideas by investigation. It was interesting that a number of the pupils chose to use sensors in their explorations.

Remote logging was so easy with the portables that, in one school, the machines were used by other science classes in preference to the school's bank of BBC computers. Furthermore,

a senior student used a portable in a practical project which won a commendation in the Intermediate Biological and Ecological Section of the *Aer Lingus* Young Scientist Competition. Teachers did not always take full advantage of the flexibility that portables gave in data capture beyond the confines of the classroom. Only light, temperature and position sensors were available to the schools during the project and it is considered that the provision of, for example, pH and oxygen sensors would allow more comprehensive environmental monitoring.

Although much use was made of the measurement capability of the machines, suitable hardware and software was not available in the schools to enable them to use the portables in typical control contexts such as traffic light simulators or burglar alarms.

Awareness of what IT offers

A major aim of IT in the curriculum is that pupils should come to an awareness of a range of ways in which it might be applied and an appreciation of its potential significance in their own work and in the work of others. Giving individual pupils virtually unhindered access to personal computers makes an major contribution to achieving this. On occasion such awareness was explicitly taught in the project schools. In one class, pupils plotted a graph first by hand and then on their portables, and subsequently discussed the effectiveness of using computers in meeting their needs in this specific situation. More important, however, was the 'hidden curriculum' of the personal computer. Pupils were continually confronted with the advantages and the disadvantages, the strengths and the weaknesses of the new technology. This was an experience not usually gained in traditional approaches to IT provision.

Assessment

Continuing developments in assessment practice in some cases request, and in other cases require, that teachers assess pupils' attainment in IT-related issues in science in a much more systematic way than previously. This calls, firstly, for the identification of appropriate opportunities where pupils may deploy,

and hence develop, a range of skills; and, secondly, it calls for opportunities for teachers to observe pupils exercising these skills in a range of contexts. These dual demands represent a considerable challenge; the science teachers felt that a strength of the provision of personal computers was the ability to meet this challenge. The use of the portables allowed plenty of opportunities for the observation of pupils at work and plenty of scope for dialogue with individual pupils about that work. This may not make assessment simple, but it does make it possible and teachers felt confident that they would be able to comment on aspects of individual pupils' performances in terms of IT in science or in IT *per se*, if that were required. Despite some early interest, no attempt was made to use the portables for holding and presenting drill or test items, nor for storing pupils' self-assessment schedules.

Lesson planning and preparation

Before the project began, teachers in those schools with a focus on portables in science were already using IT to support their work with pupils. However, because of involvement in the project, they felt themselves under additional pressure to seek out opportunities to incorporate portables into their lesson plans. In one sense this was made easier because the start of the project coincided with the introduction of a new science programme of study with the result that schemes of work were quite fluid. In another sense this was made more difficult because the science departments were simultaneously dealing with a new curriculum, new approaches to assessment and, in one case, a general inspection.

The use of portables added to the burden of preparation for teaching and learning. It was clear from the outset that teachers need time to try out procedures on the machines before lessons. Time is also required to prepare lesson resources, such as step-by-step instructions to support pupils as they work with their computers. In addition to the need for time to prepare materials and activities, it should be noted that teachers reported time lags of up to three weeks against the normal schedule of teaching.

This was largely due to the time that teachers and pupils needed to familiarise themselves with the machines. Although the effect was reduced by the end of the school year, the use of portables in the classroom continued to make extra calls on lesson time.

Teaching and learning styles

Teachers reported that the use of portables by pupils had not dramatically altered their own approach to classroom management nor had it changed their teaching style. It was suggested that, because science lessons are lengthy and involve practical work, computers may be less intrusive than in other subjects, and that since there is routinely much more flexibility in time and pupil movement in science classes, activities such as typing and printing may be more readily accommodated in the course of the lesson. Nevertheless, some aspects of teaching style were found to be different. Teachers reported, and the research team's observations confirmed, that they had had to become more mobile in the classroom and that they interacted more with individual pupils. These extra interactions, however, were mostly about queries or problems with the machines.

The project demonstrated that an IT-rich environment, such as is afforded by the provision of portables, can assist substantially in the delivery of the science curriculum. One teacher summarised it thus, 'I think it is possible to meet all the requirements of the curriculum using the portables. Indeed I do not think it is possible without them. Certainly, it would be very difficult'.

Science teachers felt that having portables had proved a very positive learning experience for the pupils concerned. They had become confident and competent users of the technology and had extended and enriched their experiences in science. Many had gained a sense of achievement through the standards of presentation possible with wordprocessing and through the effectiveness of using the machines for gathering, handling and communicating information. Success had bred success and, overall, this study showed that portable computers can effectively fulfil the IT-related dimensions of the science curriculum and can enliven and enrich pupils' learning experiences.

Portables in the mathematics class

The project demonstrated that there was no aspect of the mathematics curriculum that the portables could not facilitate. The overwhelming view was that the convenience of their access, in offering desktop computer power on each pupil's desk, has major potential in the mathematics classroom.

Information technology and the mathematics curriculum

The different mathematics curricula in Scotland, England and Wales, and Northern Ireland contain more or less the same elements of pupil learning. They differ mainly in presentation, and a little in emphasis. The curricula divide into groupings which are variously described as attainment outcomes or targets. For our purposes we will use the following generic versions of these elements including the target for pupil learning which is related to mathematical *process*: problem solving and enquiry; and the targets related to the *content* of mathematics in terms of concepts, facts and techniques: data or information handling; number and measurement (including patterns, sequences, functions and equations) and shape, space and movement.

The process target is used by teachers to assess pupils' problem-solving abilities, ie their skills in planning mathematical strategy, conjecturing, generalising and communicating mathematical ideas effectively. Content targets are used to gauge mathematical knowledge.

Information and data-handling. Aspects of the information and data-handling targets addressed directly in the classrooms using portables were interrogating data in a computer database; and inserting and interrogating data in a computer database and drawing valid conclusions. In a number of instances pupils undertook this type of activity spontaneously on their own data (for example for creating a database of a collection of music CDs). A further aspect directly addressed was producing various forms of representations of data. Here, portable computers proved useful in augmenting pencil and paper exercises on pie charts, bar charts, line graphs and so on. They were particularly useful in enabling pupils to investigate differences in data

representation and interpretation in the various formats quickly and conveniently. There was also evidence of these skills being exploited to create bar graphs in both science and home economics classes.

Number and measurement. In the 'number and measurement' area there were routine examples of pupils using the calculator on their portables (in one case the class found and began using this independent of their teacher who had not realised it existed) and also of using spreadsheets to look at interest accrual on money saved or borrowed over time (a number of schools used a spreadsheet to investigate and compare simple and compound interest). Practice on changing units was also easily accomplished. Independent working was again in evidence with, for example, one pupil maintaining his own bank account on a personal spreadsheet. Because of the age of the majority of pupils it was not possible to gauge the contribution portables might make to higher level aspects of problem-solving such as using spreadsheets to investigate the feasibility of a mini-enterprise or business project. However teachers could anticipate no difficulty in using portables to deliver and assess such work.

Shape, space and movement. The following aspects of 'shape, space and movement' targets were addressed directly using a Logo package: investigating position in terms of angle and distance; and devising instructions to produce desired shapes and paths. These were exemplified by drawing equilateral and isosceles triangles and then extending the work to the drawing and calculation of angles of regular pentagons and hexagons. Understanding Pythagoras' theorem was also considered by teachers to have been assisted through use of the portables. Logo was used to plot coordinates, investigate angles of turning, estimate distance and to produce various shapes and repetitive patterns, eg a square followed by a rotation of 3.6°, repeated 100 times. A third aspect directly addressed was generating and transforming two-dimensional shapes. Here, transformations were accomplished using repeat procedures with constant change of angle and moves to different coordinates on the screen.

Using spreadsheets

Spreadsheets offer a powerful medium for pupils to tackle the various 'trial and improvement' methods which form the basis of solving equations step by step through iteration, while access to portable computers allows the teacher to illustrate method conveniently with each pupil. While new formulae need to be memorised as new equation types are encountered, the iterative method applies for all equations, thus making the convenience of access to computer power through the use of portables invaluable. For mini-enterprise or business project work, the access to computing afforded by portables permits pupils to use full year profit/ loss and cash flow spreadsheets to undertake feasibility studies. Less full access, as when access to a network has to be booked, would militate against carrying out a study which accurately reflected the 'real thing'. A class equipped with portable computers can follow the formation of the company from initial market research to the calculation of the overdraft which will secure the well-being of the business. In this manner a superficial exposure to modelling can soon become a detailed insight into the application of mathematics to business.

Graphs come up almost daily in the maths classroom and play an important rôle in the curriculum. All the national maths curricula suggest that pupils should be able to generate various types of graphs on a computer (or a calculator) and interpret them. Immediate access to graph-plotting software makes checking pencil-and-paper work easier but more importantly it also encourages the pupil to explore. A pupil is more likely to internalize the concepts of gradient and intercept, for example, if asked to explore the family of curves governed by the equation $y = mx + c$ for various values of m and c. Moving on, computer-based graph-plotting facilities allow the pupil to ask and respond to 'What would happen if...?' questions, such as 'Given the graph of $y = sin(x)$, what will the graph $y = sin(x/2)$ look like?'

Using Logo

Logo is a popular computer language for teaching and learning mathematics. There are many claims and counter-claims about

its worth in the classroom, thus, for example, Papert's claims for Logo, in his book *Mindstorms*, have been the subject of many research studies. However Logo does not make a significant contribution to the mathematical *content* target of 'shape, space and movement' since polar coordinates and transformation geometry do not arise frequently in the mathematics classroom.

Papert asserted that children acquire problem-solving skills essential to their mathematical development through investigating using the Logo programming language. He and his followers consider that children who learn to program in this language improve in logical thinking, become better problem-solvers, become better at locating and correcting errors in mathematical reasoning, and recognise more readily that there may be many strategies for solving a problem. Logo may therefore make a powerful contribution to the process target in mathematics. The fact that children in past studies have failed to acquire strong transferable problem-solving skills from Logo might have been due to insufficient time being available for the pupils to master it. With the high level of access to a Logo environment which portable computers can offer, they may therefore be more likely to contribute to the development of the problem-solving skills of children.

Using database software

All the national mathematics curricula acknowledge the value for pupils of collecting, organising and plotting real-life data but most teachers recognise the amount of time this can take up. Portable computers can remove the tedium of assigning data to intervals, tallying and constructing bar charts, enabling pupils to concentrate on the higher level skill of interpretation of the summarised data. Statistics and probability have a central place in the curriculum and the portable computer can also provide the opportunity for convenient exploration of real-life data.

Using drill software

All the national maths curricula also require pupils to have skills in mental arithmetic. Regular access to drill and practice software

(usually in the form of multiple choice or true/ false type questions) has been shown to improve number skills. A survey of the research on the computer-assisted learning of number skills, carried out by Roblyer in 1985, showed that pupils with regular access to drill software demonstrated significant gains over pupils using more traditional methods for learning number facts. The levels of access necessary to ensure long-term improvements are, however, probably only achievable with the high degree of personal access to computers that is offered by portables.

Pupils working autonomously

Overall, there was much evidence of pupils using the machines independently in mathematics – with database and spreadsheet work featuring prominently. Pupils appeared to learn very quickly, including relatively complex activities in Logo, and the extent of peer-support and collaborative learning moved one teacher to say, 'I'm amazed... at the spontaneity of work produced right across the spectrum ... at the exchange of skills and information... I could abandon the class and they could teach each other!'

In summary this study suggests that the potential for portables to provide convenient facilities for regular or spontaneous classroom work in mathematics seems well-founded. In addition, the project demonstrated that higher order exploratory work in mathematics, using Logo and other investigative computer environments, can realise greater benefits as a result of the portable's convenience within the classroom context.

4

PORTABLES IN THE CLASSROOM

THIS CHAPTER reports on the implications, for schools and teachers, of day-to-day teaching of classes with portable computers.

Developing teachers' IT competence

None of the English focus teachers felt that they had been competent with information technologies before the project started. They felt they had had to work hard to come to terms with hardware and software, and to plan the integration of the portable into the curriculum. There was a general feeling among the teachers that a fairly high level of training and support would be necessary for them to integrate portables properly and effectively into their lessons. One teacher had used the local education authority technician regularly in her classroom for technical support. Others had relied heavily on school technicians or IT coordinators to help them over the initial hurdles of familiarising themselves with the machines, printing and so on.

All the teachers reported having to spend a great deal of time familiarising themselves with the machines before they felt confident to plan and conduct purposeful lessons. The tutorial on the Microsoft program received favourable comments in this context. A degree of help and support from experienced colleagues and particularly from pupils was also reported. A number of the schools had information technology technicians, some full-time and some shared with other non-project schools, and this support was considered invaluable. All the teachers felt that their IT skills had developed considerably with consequent development of morale and confidence. They also considered that the portables had provided them with opportunities for innovative teaching approaches and looked forward to a more effective use of the technology the following year.

There was consensus among the teachers that in-service training (INSET) remained high priority for successfully integrating IT into teaching. However, experience in the project had convinced the teachers that a particularly effective way of providing for the training needs of teachers would be for all teachers to have a personal computer, preferably a portable computer which could be easily taken between home and school. It was felt that the high level of personal access had enabled the teachers to familiarise themselves more effectively with IT, allowing them to integrate IT into their teaching schemes more effectively. During the project, some of the non-focus teachers who were teaching pupils who had portables complained that they also needed portable machines in order to prepare lessons for the class.

Implications for the teaching schedule

For the first month a considerable proportion of lesson time was taken up with computer-related activity (either familiarisation or technical problems) and at least six teachers considered their class to be behind in the teaching schedule. For most classes, teachers considered that most of the lag had been caught up by the middle of the second term but the science and mathematics teachers still felt their classes lagged behind others in the year group on account of the amount of lesson time being spent on computers.

Lesson length

Periods at least one hour long, such as a double (35 to 40 minute) period, were generally considered to be the minimum for a portables-based lesson although the machines with hard disks were frequently and successfully used in single 35-minute periods. In the primary school it was usual to give over an entire morning or afternoon to using the machines. In one of the secondary schools, the teacher's original single-period timetable had been changed to allow double periods.

The prime reason was the time needed at the start of a lesson for taking out and starting up machines and at the end for saving

files and shutting down. At the beginning of the project the time taken was considerable – anything up to 20 minutes to get all pupils and machines ready with perhaps ten minutes at the end to have all files saved properly – but by the end of the project start-up time was down to five minutes at most, the time at the end ranging from one to five minutes depending on the type of activity. However, at least two of the teachers reported that on occasions the start-up and shut-down processes could be much longer. One method of saving a significant proportion of lesson time was to have the pupils carry out preparatory work (such as data input in a database file) at home.

Planning and pacing lessons

The reaction of science teachers to fitting the use of portables into their teaching has already been discussed. Generally, in the early stages of the project, the teachers reported, in their post-lesson diary notes, that they were over-ambitious in their lesson planning and had not mastered the pacing of lessons based on using portables. As time went on, and teachers and pupils became more adept, this problem was much reduced.

Some lessons, however, continued to overrun with pupils having to finish work at home or carry it over to subsequent lessons. Having to deal with technical problems was a persistent cause of some lessons not being completed. In most cases portables were planned into a series of lessons rather than one-off activities.

Technical support

All teachers commented on the amount of time they had to spend resolving technical problems. On average, at least one battery would go flat per lesson; teachers considered that disruption to teaching (to sort out the problem) reached an intolerable level when more than three such events happened per lesson. Early in the project disruptions due to battery and disk problems accumulated over the lesson period, amounting in some cases to 30% of the lesson time. Clearly these problems seriously disturb lesson delivery.

Teachers as providers of technical support

Teachers with portable computers in their classes had to adopt a new rôle, that of a supportive technician dealing with software-related problems (eg, wordprocessor or database functions) or directly with hardware problems (especially those related to batteries and disks). While it could be argued, perhaps, that science teachers at least would be familiar with the idea of providing technical support to pupils in a lesson, it was clear that such a rôle was not familiar to teachers of mathematics or English, and is unlikely to be familiar, or indeed welcome, to most teachers.

All the teachers felt that technical support in the classroom would be needed to retain the fluency of normal teaching and some alluded favourably to the 'network' room situation where setting up the hardware and software was automated and where someone else had responsibility for dealing with technical problems. We will take up the question of 'portables versus networks' shortly.

Decreasing the impact of problems

Set against the case for technical support on site, there was evidence that by midway through the second term the problems of classroom management and organisation had reduced as the pupils and teachers became more skilled and novelty gave way to a more purposeful approach to use of the portables. Teachers reported being much more confident in the face of problems which now fell into familiar categories. Problems which could be dealt with quickly were tackled while those recognised as being more difficult were set aside and not allowed to take up lesson time. While such problems (simple and complex) became much less frequent, it was clear that some would always exist and therefore would cause some level of disruption both to the teaching flow and to the work of the pupils concerned.

Networks versus portables

At present, the provision of a network or networks of computers is the most frequent pattern for access to computing in schools

but the project has identified four principal advantages that portables have over networks.

The first relates to flexibility in lesson planning. Teachers usually have to book access to a network in advance, an arrangement whereby the lesson moves from its normal setting to the computer network, perhaps for the same weekly period or periods for several weeks. As an example, a typical series of lessons to illustrate the application of databases to statistics might begin with instruction on the fields and contents of selected datafiles. However, a substantial portion of the second lesson will often have to be devoted to revising information from the previous week's lesson before further teaching is possible. Portable computers allow for much more continuity in the lessons and therefore remove the fits and start aspects associated with intermittent network access.

The second is that portables permit pupils to practice at home. The teacher may set homework exercises where pupils practise basic information technology skills, such as an elementary database interrogation. Pupils are more likely to experiment at length in their homes and more likely to return to the classroom the following day with a clear understanding of simple interrogation procedures. Portable computers therefore offer the teacher the opportunity to begin the next lesson on, for example, more advanced interrogation methods with the reasonable prospect that the pupils would be ready for them.

The third is that the use of portable computers can assist the integration of information technology into the curriculum, one of the central aims of modern curriculum design. The physical move to the computer network may serve to distance information technology from the subject in which it is being used since the network room is unlikely to have the same range of appropriate and accessible resources. The use of portable computers in each subject's normal classroom emphasises that information technology provides powerful tools for the subject.

Finally, there are the benefits of accessibility and convenience. Teacher autonomy is much improved through access to portable

computers. Network time often has to be negotiated well in advance with the result that teachers often find themselves rushing a topic or truncating a series of lessons in order to take full advantage of the network sessions offered them. Portable computers, on the other hand, allow teachers to use information technology to support their teaching when and where they feel it is warranted. Thus, in order to illustrate the properties of polygons in mathematics, the teacher may introduce the topic using Logo on the portable, then present some geometric theory using traditional pen-and-paper activities and continue the topic by returning to computer-based teaching. In addition, there are many unplanned teaching opportunities in every subject, arising from questioning or from a pupil's request for clarification. Access to portable computers greatly aids computer-assisted follow-up where this is appropriate.

Two of the teachers in the study preferred the security of network provision, having experienced serious problems with machines which had later to be withdrawn. The majority, however, considered that the following advantages outweighed the constraints of network or stand-alone desktop provision. They valued: the accessibility of portables and their immediate availability when a suitable opportunity presented; the continuity possible from one lesson to the next (with the added bonus of using the machines at home in the intervening period); and that each pupil was afforded a personal learning environment when the need arose (particularly appreciated in mathematics and English). The number of machines which could be made available to pupils in the science laboratory was also very important for some science practicals involving, for example, sensor equipment.

Teaching issues

'New' modes of pupil contact

As already noted, the science teachers felt that their teaching approach had not greatly changed. A number of teachers across the project commented upon having to spend much more time going around the class, dealing with pupils' enquiries individually

and close to, rather than as an answer 'across the classroom' since pupils' queries often required teachers to be directly behind them looking at their screens. This was a new and unwelcome feature of lesson management for several teachers.

Teaching effort

The combination of having to teach taking account of the portables and of having to cope with hardware and software questions and problems, was reported by all the teachers as leaving them feeling drained. Although this reduced considerably as time went on and use of the portables became more routine, teachers still considered there was an added intensity to the lesson arising from the effort needed to integrate the portables into teaching.

Pupils without machines or disks

On occasions when machines went 'down' in a lesson or when pupils didn't have machines (having forgotten them or having returned them for repair), teachers were faced with coordination problems which drew heavily on their time and effort. In some cases it was felt that the pupils deliberately forgot to bring machines (or disks) either to avoid work or simply to avoid having to carry them. Such instances cause more disruption more than, say, a forgotten book does, as the sharing of machines and files is not so easily arranged. That some pupils did deliberately forget to bring equipment, although these formed a tiny minority in the classes observed, serves as a reminder that portables did not enthuse all of the pupils all of the time.

Catering for absentees

The normal problems of enabling absentees to catch up with class work were also found to be compounded, as teachers had to spend time 'at the machine' to direct the absentee's work or to organise the sharing of files, instead of simply directing that a piece of work should be done. Where the work involved the use of peripherals (such as a sensor in science), setting up the specialised equipment added to the diversion of teachers' time and effort.

Printing out pupils' work

Producing pupil work in 'hardcopy', ie printed output, invariably suffered from the twin problems of a lack of printing facilities and the printing capabilities of the software and hardware used. This included, for example, the speed of printing.

With the exception of sensors in science, printers were the only peripherals seen to be used, and these were used heavily. It was not unusual for printers to be in use both throughout a lesson and after it had ended. The number of printers in the portable computer classes varied from two to five. No classes used machine-to-machine downloading but several had transferred files from personal disks to desktop machines. Most pupils printed from disk (or left their disks behind so that their files could be printed from them) but some did connect their machines directly to the printer cables without any reported problems of damage to the interface. The amount of paper used per pupil ranged from one page in a science or mathematics lesson to as many as seven in an English lesson.

Enabling pupils to access printers was a major problem, especially when the printed material was required within a particular lesson. When the material was not needed immediately the problem was reduced but still required printing to be organised and coordinated by the teacher, by technical staff or by pupils after the lesson. In most cases this meant the use of 'free' time (by teachers and pupils) before lessons started in the morning, at break and lunch times, during registration periods and after school. The consensus was that printing facilities need to be organized in a manner which does not require the intervention or attendance of the teaching staff, except when printing is required in the lessons themselves.

Printer noise was considered to be a major disruptive factor in lessons. Both pupils and teachers needed to raise their voices in order to be heard and the noise was considered to be an environmental factor which militated against good classroom working. In one case, to lessen the disturbance, the printer was set up in the corridor. It is likely that printer silencer hoods or

relatively quiet ink jet printers would reduce this problem but none of the schools had adopted these solutions.

Speed of printing was also reported as a major nuisance factor with a particular complaint being the need for up to five minutes to print out a pupil's graph. With perhaps more than 30 pupils waiting for print-outs in a mathematics class the situation can become untenable. Some teachers resorted to printing out a small selection of such graphs and then photocopying them for the rest of the class. This, of course, is a software matter and faster printer drivers should be available in the future.

Contingency strategies

The teachers developed a number of contingency strategies for reducing the 'technical interruptions'. These included having:

- spare machines (if available) ready for replacing ones which had broken down
- charging facilities ready to use
- printing facilities at the ready (paper loaded and so on)
- instructions ready for any work not completed and having to be completed at home
- sharing arrangements
- a supply of spare disks (with any necessary working files pre-installed) in cases where machines using floppy discs were the basis of provision.

School and classroom organisation

Issues related to the school and classroom context are very important when considering the introduction of portables. This section raises a variety of concerns including matters related to power sources, furniture and accommodation. Readers should note that the pace of improvement in hardware and software means that some matters such as screen visibility in low-lit classrooms are in fact diminishing problems.

Aspects of the classroom

Ideally a 'portables classroom' is a bright and airy room, arranged in group tables with ceiling-suspended power sockets. The

group tables give that little extra desk space which pupils need for their portables. However some teachers, who had been offered rooms which had better facilities for use of portables than their usual rooms, preferred to accept the inconveniences rather than move from the room where they were most comfortable in their teaching and which offered the necessary resource base for their lessons. In some cases, small rooms, in most other respects satisfactory for the group, were found to be very cramped for lessons using portable computers.

It was especially difficult to organise supplementary charging when batteries were spent. The lack of suitable powerpoints in some rooms compounded the difficulties of charging 'flat' machines and the 'trailing leads' of the battery charging transformers, and of any shared 'four-gang' power leads, gave rise to safety concerns.

Some types of classroom furniture (for example one-pupil desks) were found to be unsuitable for using portable computers. Small desk-tops made the use of machines, and any attendant paperwork or books, very difficult to manage. Larger four-pupil tables were found more suitable both to manage the various resources and portables and to enable pupils to engage in cooperative work when that was appropriate.

Lighting and screen quality

Back-lit screens were by far the most popular and were considered the most appropriate for classroom use, with the VGA versions (in the RM Notebook 201s) being particularly well received. Liquid crystal display (LCD) screens were roundly criticised as being difficult to read and awkward to set for lighting conditions and angles of incidence.

Classroom lighting also presented problems in some circumstances. In bright sun-lit conditions direct light falling on the back-lit screens made them uncomfortable to read, while low light conditions on the liquid crystal display machines had a similar but more pronounced effect.

Location of equipment

During the project all the schools at some point allowed pupils to take the machines home but by the end of the project one school had stopped this because of an unacceptable level of forgotten and uncharged machines. Most schools made provision for pupils to leave machines in school overnight if they wished but this was discouraged for security reasons. Over the whole project only one machine was stolen and this was taken from school premises (after an appeal from the headteacher the machine was returned anonymously). As the project progressed more and more pupils chose to leave their machines in school if they didn't have specific work to do at home.

Power

The machines were all fitted for mains operation and mains charging of rechargeable batteries. The recommended charging periods varied from 4 to 10 hours, while the lifetime of fully charged batteries was variously quoted as between 2.5 and 4 hours. In practice, batteries discharged in less than two hours in most circumstances although it should be noted that all the machines, with the exception of the Apple Powerbooks, were floppy-based and therefore most activities would have consumed power relatively quickly as a result of accessing floppy disks. Hard disk machines consume power at a comparatively slower rate.

All the schools had initially made arrangements for charging the machines' batteries in school but in one case had stopped allowing pupils to take machines home and had also stopped charging in favour of using mains electricity. In this instance the machines were delivered to the classroom on a trolley and power was provided through wall sockets. In another school the lack of powerpoints (with only one old-fashioned 5 amp socket) made it necessary for most of the pupils to charge their machines at home.

The most common batteries, Nickel-Cadmium (NiCad) rechargeables, suffer from 'memory' problems. When a battery is only partly discharged and is then connected to the mains for

recharging, the battery does not fully recharge although it gives the appearance of having done so. The battery 'remembers' the charge-discharge ratio and each subsequent charge-discharge cycle results in a reduced charge capacity although it never falls below 75% of its true maximum. However, rechargeable batteries have finite life-times and may reduce to 60% of their original capacity after 500 charge-discharge cycles. Manufacturers recommend that batteries should be completely discharged once a month to return them to full capacity. The experience of the project was that the concept of battery 'memory' was too subtle for most of the pupils and teachers with the result that the batteries in the machines had varied charging histories and charge levels.

The Apple Powerbook used in the project had a 'sealed lead acid' battery which, while not prone to the same 'memory' problems, is generally less robust. For example if left discharged for long periods, maximum capacity may fall to as little as 50% of the original. It is also reckoned that NiCad batteries have up to four times the life-span of sealed lead acid types. Both types of battery represent a significant proportion of the total weight of any portable machine and advances in battery technology in combination with solid-state memory storage as an alternative to disk drives are needed for desirable power and weight improvements.

Software

Ease of use

The teachers expressed concerns about the ease of use, for both the pupils and themselves, of the software supplied and especially the database and spreadsheet packages. Indeed it had been difficult for the teachers to assimilate the processes themselves and then to pass these on to pupils. In one case a teacher explored the possibility that, with the pupils being so technically literate (about half way through the project), they would not require the step-by-step worksheet approach used hitherto. He provided the instructions verbally for a particular spreadsheet activity but in the end had to record his dismay (though not surprise) that

pupils still could not absorb the key sequences needed to carry out the functions. He resigned himself to continuing to develop worksheets and to much verbal repetition of instructions. To some extent this is not an unexpected perception of the ease of use of the MSDOS version of the Microsoft Works software he was using, the Apple and Windows versions being considered to be easier. The ClarisWorks software on the Apples was found to be reasonably easy to use. It is important to note that the easier a package is to use, the less likely it is that technical queries will disrupt lessons.

Variety of software

The variety of software used in the project included wordprocessors, databases and spreadsheets. Logo work was facilitated through the use of a specially commissioned package called QLogo and data-logging was supported by the Educational Electronics/NCET Sense and Control package. One teacher used a desktop publishing package, called Newsmaster, very effectively on the Toshiba T1000SE. Some of the teachers identified software packages they would like to have had for their classes but in the main they were unable to afford to purchase them. Others complained that they did not know what was available for the machines they had or that the software which the school already had, particularly science simulation software, was not compatible with the portable machines. Although the IT literacy of the teachers increased dramatically over the period, they remained relatively ignorant of hardware and software compatibility and of the sources and procedures for acquiring software.

Virus protection

The Apple Powerbook 100 had external floppy-drives which the school concerned chose not to give freely to pupils. This had the school's desired effect of controlling the extent to which the machines were used for playing games and also of preventing virus problems. Virus infection on hard-disk machines is a significant problem, especially with the amount of games software being exchanged for home computers. Virus protection software

is therefore necessary for such machines. Floppy-based machines are much less prone to virus problems and no viruses were detected on the machines in the project.

Guides

Everyone was agreed on the need for carefully designed guide-books covering the common software packages, for both teachers and pupils. It was felt that this need was accentuated because in many cases pupils (and teachers) would be using software away from sources of technical help, in particular at home. The provision of effective worksheet-type materials was also considered necessary to reduce the level of support pupils needed when using software during lessons.

Hardware

Robustness and durability

The machines proved reasonably robust under a regime of relatively 'rough and tumble' use by pupils. Minor problems appeared early including, for example, interface/ external port covers coming off and in some cases being lost. More serious but manageable (with various 'sticky-tape' remedies) problems were the dislodgement of battery cover doors and, in the case of the Apple Powerbooks, tracker ball 'click' buttons. Most machines quickly developed a top-to-bottom mis-match of the two hinged halves (in the form of a slight overlap) but this did not appear to affect their working. Many of the early NB100 machines, however, developed screen hinge cable faults which caused their eventual withdrawal. The Powerbooks also experienced problems associated with their power-line connectors.

Reliability

Four schools were initially equipped with a machine which had serious problems of reliability and which was eventually withdrawn. The teachers involved experienced varying degrees of frustration, disappointment, anger and despair at the level of machine problems they had to deal with. One school gave up altogether at the end of November 1991, owing to the breakdown

of 75% of machines, and only started again in mid-January 1992 when the machines had been replaced *en masse*. In another, work was suspended from mid-December 1991 until the arrival of the replacement machines at the start of January 1992. The diaries of the pupils concerned were particularly graphic: 'I'm starting to think computers are a waste of time because they keep breaking...' and 'I don't really like the computer because it causes so much hassle...' These experiences reinforce the idea that machines must be reliable if they are to be successfully integrated into the classroom.

Protective carrier bags

The incidence of machine breakdown was significantly less for those who had protective covering or bags for them. The primary school, for example, suffered a slower breakdown rate of machines than the two secondary schools which used them to the same intensity and which also allowed pupils to take machines home. The machines in the primary school were protected by a cover designed and made by the teacher using a simple fold-over document envelope with a plastic bubble-packaging liner, while the machines in the other two schools were carried unprotected. It was not clear how the protection could have affected the breakdown rate particularly as the main problem centred on the ribbon cable in the hinge connecting the screen to the lower half of the machine's clam-shell. It should be noted that there was no indication of pupils abusing the machines. Work also continued in the remaining school which had the same machines but here the level of usage and consequently the level of breakdown had been relatively light since the beginning of the project.

From around January 1992 all pupils had some form of carrier protection for their machines. In most cases this was a shoulder bag supplied by the project or the manufacturers; in two schools wooden carrier boxes made by one of the schools' craft departments were available. In one school a decision was taken not to give out the manufacturer's recommended bag as it was felt that it would make pupils conspicuous going to and from school and would therefore make them vulnerable to bullying or

other mischief. It should be noted that pupils did not like the bags or boxes because in their own words they were not 'cool'!

Portability

Pupils regularly complained about the weight of the machines, especially when they had to carry them in addition to PE kit, musical instruments and other items. The weight of laptops, at around 5-7 lbs, remains a considerable disincentive to pupils carrying them at all times and it is felt that the weight would need to drop to 1-2 lbs before this would be alleviated.

The lack of a handle, while not expressly mentioned by pupils, was clearly an additional factor as pupils were observed to be uncomfortable, and even a little concerned about losing grip, when they handled them 'clutch bag'-style. With the considerably lighter WP2 wordprocessor machine this did not appear to be a problem. Some of the teachers felt that while a handle was probably a good idea for moving the laptop from place to place (such as bag to desk) it would not help with the problems related to carrying chargers, mains power adaptors or disks where some kind of carrying bag would still be needed. In the special school the carrier bags were particularly appreciated because they were easily hung over wheelchair handles.

Warranty and non-warranty machine problems

Aside from the inherent problems associated with one of the chosen brands of portable computers, machines which 'went down' fell into two categories: those with warranty supportable faults such as screen distortion, partial loss of screen; and those which had suffered accidental physical damage (screen breakage, breakages in the casing) and which therefore fell outside warranty conditions. The incidence of the breakages of the second kind was low (less than one per school over the project) but less serious but no less disruptive problems such as disks jammed in disk-drives were relatively common. In a number of instances disks became corrupt through having been carried in blazer pockets and pencil cases. In some cases teachers who were not sufficiently technically literate returned machines which were

not actually faulty, examples included machines returned with only the batteries flat, machines which failed to read disks which then turned out to be dirty and machines which had been configured to provide a US keyboard layout on start up.

Supplier support

The suppliers for the most part displayed a considerable goodwill by fixing non-warranty problems at no charge although it was not always certain that the schools appreciated the distinction and therefore the gesture. As the project went on at least one teacher complained of finding it more difficult to contact the suppliers. The combination of machine 'breakdown', limited teacher free time and suppliers' 'lack of urgency' can lead to much frustration as the following experience illustrates:

> A pupil complained that his password (which the machine allowed him to set) was not working. The teacher tried it without success and decided that the pupil had forgotten the password he put in. The pupil was adamant he had not forgotten but in any case the teacher realized that the only solution was to contact the dealer to find out how to override the password. The dealer said they could not give that information and the teacher must contact the supplier. The teacher telephoned the supplier's 'hotline' and faced several lectures on the need to remember passwords when they are set... Eventually, after three telephone calls to the hotline, he was advised to put his request in writing since, for security reasons, a telephone request could not be attended to. With written details of the serial number and warranty dates he finally received the password override codes and was then able to use the machine. To his surprise he found the password had been correct and that nine keys on the keyboard were actually faulty. These had caused the password to be read incorrectly by the machine (he had been lucky the override code did not involve any of the keys). The whole process took three weeks, a lot of teacher time and one pupil completely without a machine.

Password protection

The previous section outlines the difficulties which a password facility can cause if it is accessible to the pupils. No reasonable

use for the password facility could be found for machines based on floppy disks and the potential nuisance value may make it undesirable for hard disk machines unless control rests with the teacher.

Insurance

A number of the schools negotiated insurance to cover accidental damage to the machines. In some of the 'maintained' schools (those retaining a degree of church control) the machines were included in their normal policies arranged by their collective organization while the 'controlled' schools (those wholly managed by the local authority) sought individual arrangements with the local authority or commercial insurance groups. As might be expected, the choice of having or not having insurance was not simple since, on the one hand, the premium and, on the other, a screen breakage can each cost as much as half the original machine price.

Disk storage

With the exception of the Apple Powerbook 100 which had an internal 20 megabyte hard disk fitted as standard, all the machines had 1.4 megabyte floppy disk drives. These high density disks enabled major software packages such as Microsoft Works to be provided on one disk. Other machines of similar specifications to those used in the project have 720K drives fitted, with the consequence that much software which would fit on 1.4MB disks would require two disks, thereby raising the possibility of not being usable or, if usable, then presenting the attendant inconveniences of disk changing and increased power consumption.

For optimum usage of available software such as Microsoft Windows, a hard disk is necessary. The teachers in the project took the view that if schools do buy portable computers they should at least provide teachers with hard disks, if providing them in pupil machines is not possible. Where floppy disk-based machines are to be purchased, drive specifications should be high density to get the best from them.

User interface

Apple. The Apple Powerbooks had the familiar Apple interface with an in-built trackerball just below the keyboard. Two curved click bars were available above and below the trackerball, worked by clicking with the tips of the fingers at the front or with the wrist-hand joint at the back (each having the same effect). This arrangement gave problems arising from hitting the spacebar instead of the front click bar and vice versa. It was suggested that the bars would be more conveniently placed to the right and left of the trackerball to be operated using the thumb or little finger respectively. With respect to software facilities, the Apple interface was the same as its desktop equivalents, offering the usual ease of use and cut-and-paste type facilities. In common with other portables, the screen pointer suffered 'ghosting' effects, that is fading track of the pointer as it moved across the screen.

IBM Compatibles. The IBM-compatibles were all floppy-disk based machines and therefore unable to provide interface with Microsoft Windows. Software for the machines was therefore wholly keyboard-driven and much less easy to use. Teachers commented on the difficulties which they and pupils had in remembering key combinations in the various systems, and in particular the cut-and-paste routines of the MSDOS version of Microsoft Works. Most machines now have integrated hard disks so these problems are likely soon to disappear.

Memory

Extra machine memory can considerably improve performance and save on power consumption. The common configuration of machines at present is 1 megabyte of random access memory (RAM) and all of machines in the project had at least 1MB RAM, 2MB in the Apple Powerbooks. With MSDOS (IBM-compatible) machines, portions of any installed extended memory can be configured to create a 'silicon disk' which then acts as another disk drive without the moving parts which consume power in normal disk drives. Using programs and files copied on to the 'silicon disk' from conventional disks is virtually instantaneous and miserly on power consumption, leaving the

original copying action and the final saving action (since the silicon disk loses its contents on switching off) as the only disk accesses necessary. It is therefore felt that in selecting machines more than 2 megabytes of RAM is desirable with much more needed where the proposed software so demands.

To a great extent the usefulness of portable computers relates to the fact that they are essentially desktop computers that can be conveniently moved. Yet therein lies their main problem. While developments will continue to improve screens, memory availability, power consumption, disk storage and so on, the general 'rough and tumble' of being carried around by school pupils may well continue to provide maintenance and repair difficulties for schools. In the hands of the typical business executive, modern portables are reliable and robust but schools are likely to need to develop technical support procedures to ensure continuous availability of working machines.

5

SOME CONCLUSIONS

THE PLAIT PROJECT covered a variety of aspects of the use of computers in the classroom and gave rise to a series of recommendations and conclusions. Many of these relate to policy and concerned such matters as the views of school management perspectives and parents' views. In relation to the possible contribution of personal portable computers to teaching and to the curriculum, in particular of the core subjects English, science and mathematics, there was a reasonable consensus among teachers.

In **English,** pupils with their own portable computers can make sustained and purposeful use of wordprocessors and desktop publishing software. Most of the learning outcomes in writing can be addressed through wordprocessing and desktop publishing and there are notable benefits to be gained from the use of spell-checking and thesaurus facilities.

In **science,** pupils can usefully make use of:

- wordprocessors and spreadsheets (these lend themselves particularly well to aspects of experimental work – writing up with the former and processing data with the latter)
- databases software (useful applications include the management of collections of data from survey or other field work, some of which may also arise from cross-curricular activities)
- sensor technology (sensor kits are now readily adaptable to portable computers and the portability of the machines holds out the promise of sensing work 'in the field').

One-to-one access to portable computers did not inhibit group and collaborative working by pupils, and indeed limited access to peripheral equipment such as sensors can be easily compensated for by using group work strategies with a smaller number of machines.

In **mathematics,** pupils can usefully make use of:

- spreadsheets for exploratory and investigatory work (such as comparing simple and compound interest) and for functional activities such as graph and chart drawing, for solving equations and for carrying out financial feasibility and other calculations
- Logo software to explore mathematical relationships in problem solving environments
- databases for studying collections of information, applying simple statistical analyses and so on.

One-to-one 'ownership' of portables was considered to have a number of major advantages over network provision in enabling work to be carried on after class and offering teachers the chance to use computers on the spur of the moment and in their own classroom environment. This was considered to be particularly beneficial in enabling pupils to engage in mathematics activities in their own time and for longer periods.

What personal portable computers can contribute to the curriculum was the central focus of this study but critical also are practical considerations which have to be taken account of if teachers are to be able to accommodate high levels of computer use within their classroom. Clearly the teachers in the project found themselves facing many new demands, in part related to technical expertise and level of computer literacy, but also in less anticipated areas such as teaching approach, pacing of lessons, layout of rooms and so forth. Chapter 4 has detailed the problems and dilemmas which teachers found themselves facing. Certain of these can be overcome by careful choice of equipment and thoughtful management, others can only be tackled within the context of inservice training and the environment and priorities of individual schools. The study has raised questions not only of equipment (what should we look for in hardware, in software) but also of role, an obvious one being in relation to technical support. Achieving balance between the requirements of the content of the curriculum in specific subjects and the aim of encouraging computer competence in pupils is also a primary concern.

The general conclusions of the study are that the portable computers in the project settings resulted, though not universally, in high levels of pupil motivation, harmonious and purposeful learning environments and greatly accelerated information-technology literacy among the pupils and teachers alike. In relation to teachers, it was clear that the convenience and accessibility of having a portable was an important factor in raising their knowledge and competence and it seems reasonable to suggest that in order to ensure that teachers are properly equipped to integrate information technology fully into their teaching repertoires, portable 'ownership' should be encouraged. It remains to be seen whether portables will become as common in our pupils' schoolbags as the now ubiquitous calculator but there seems little doubt that so long as there is a case for computing in our curriculum then class sets of convenient and personal portables will be more attractive than cumbersome and relatively immobile desktop machines.

Further reading

Details of the quantitative research findings (on learning outcomes and attitudes) are available from the authors at School of Education, Queen's University of Belfast. Limited numbers of the summary report are available from the National Council for Educational Technology (NCET). NCET has also published a report on issues to be considered when purchasing portable computers. A report on the use of portables in Scottish schools, *The Laptop Project*, is available from the Scottish Council for Educational Technology.

In addition to the specific curriculum documents listed above, readers may wish to refer to the various documents (programmes of study, non-statutory guidelines and so on) on English, science and mathematics and other subjects published by the Department for Education and the Welsh Office (available from HMSO), the National Curriculum Council (England and Wales), the Department of Education for Northern Ireland and the Northern Ireland Curriculum Council, and the Scottish Office Education Department, and the Scottish Consultative Council on the Curriculum.

References

Papert, S (1980) *Mindstorms: Children, computers and powerful ideas.* Basic Books.

Roblyer, MD (1985) *Measuring the impact of computers in instruction: a non-technical review of research for educators.* Association for Educational Data Systems, Washington, DC.

Scottish Office Education Department (1991a) *Guidelines for Mathematics 5-14.* Scottish Office Education Department.

Scottish Office Education Department (1991b) *Guidelines for English Language 5-14.* Scottish Office Education Department.

SCRE
Publication 120
ISBN
0 947833 89 7

SCRE Practitioner MiniPapers present research findings and issues to help teachers and others take account of research relevant to their work. The series includes reports of research studies, edited collections round a theme, reviews of research and teachers' guides to using research methods.

Personal Portable Computers and the Curriculum

Personal portable computers hold out the promise of putting the benefits of the power of the computer directly into the hands of pupils and at the same time of making them 'computer literate'. How might this work in practice? Can these machines help in teaching the key subjects of the curriculum? How is the role of the teacher affected? What are the implications for classroom management? for the planning of lessons? for supporting teachers?

This booklet considers the practicalities of using personal portable computers as part of normal classroom teaching across the curriculum. It is based on a study of the experience of teachers and pupils in nine schools who used computers in the day to day teaching of English, maths and science within classes of the upper primary/lower secondary age groups.

The authors are based at the School of Education, Queen's University of Belfast. The PLAIT project (Pupils' Learning and Access to Information Technology) was funded by the Department of Education for Northern Ireland.

BEST COPY AVAILABLE

The Scottish Council for Research in Education